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1. AGENCY USE ONLY (Leave Blank)		2. REPORT DATE 27 May 2002		3. REPORT TYPE AND DATES COVERED 1/1/98-12/31/01
4. TITLE AND SUBTITLE Quantum transport, magnetic field sensor, an integrated amplification in no el Si/SiGe Heterostruture devices			5. FUNDING NUMBERS DAAG55-98-1-0139	
6. AUTHOR(S) Sean Washburn				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Univ North Carolina at Chapel Hill			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U. S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211			10. SPONSORING / MONITORING AGENCY REPORT NUMBER 35059-EL	
11. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.				
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13. ABSTRACT (Maximum 200 words) Studies of high mobility Si/SiGe heterostructure devices have been analyzed in light of correlations among carriers. Single-particle models fail to describe the metal-insulator transitions observed in them. Attempts to confine the carriers and create lateral tunneling structures and magnetic field sensors have revealed ambiguous results that cannot be distinguished from disorder in the devices but which show some promise for device applications.				
14. SUBJECT TERMS Si/SiGe, high mobility, heterostructures			15. NUMBER OF PAGES	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OR REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION ON THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

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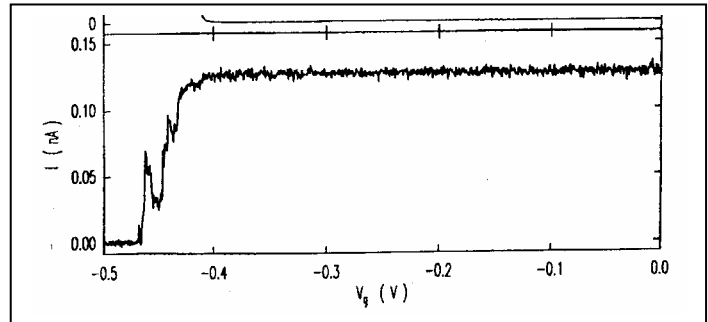
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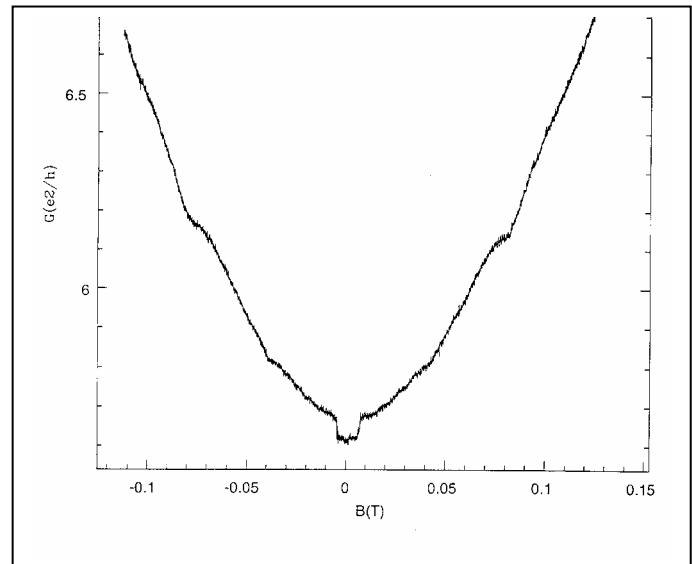
Experiments carried out during this grant have probed correlations among the carriers in two-dimensional systems. The original targets of the proposal to understand correlated motion of carriers through constrictions were attacked as described in previous reports. The results from the experiments, unfortunately, were indistinguishable from expected random signatures of the scattering from disorder in the material (see for example oscillations in the figure at right). In contrast, the results discovered incidentally from transport as a function of density in large structures led to startling results in the form of a magnetic field-dependent crossover from metallic to insulating behavior. Our research on this topic revealed that the behavior extends into very high mobility systems such as the SiGe heterostructures studied here; that the magnetic field dependence remains dramatic and hence potentially useful for devices. With further effort field sensing through the large magnetoresistance in this system might be manageable and more easily controlled than in the submicron structures that were targeted originally.



The experiments to discover possible use of SiGe structures for magnetic field sensing foundered on a subtle unexpected structure observed in the high temperature magnetoresistance. It turned out that simple classical Lorentz force estimates of the effect of the field were in error owing to oscillatory (see figure below) effects from focusing of carrier trajectories as the carriers were steered around the sample edges. These may have been enhanced by some quantum effects such as Shubnikov-deHaas oscillations. In any case the oscillations make use of such structures in magnetic field sensing untenable because of the calibration ambiguities that they present. The use of such structures to sense magnetic field is therefore discouraged.

Personnel:

3 PhD Students supported in part: (KP Li, NJ Kim and K Eng), and all of them have graduated and are now employed -- the latter two in academic postdoc positions.



The following public dissemination was supported in part by the grant.

Refereed articles:

107. "Absence of Localization in Certain Field Effect Transistors," *Superlattices and Microstructures*, **23**, 581-91 (1998). (invited) S Washburn, D Popovic, KP Li and AB Fowler.
108. "Some consequences of chaos for quantum devices," in *Quantum Based Electronic Devices and Systems*, ed: MA Strosio and M Dutta (World Scientific, Singapore, 1998); *Int J High Speed Electron Syst*, **9**, 209-22 (1998). (invited) S Washburn.
113. "Scaling and universal behavior near the two-dimensional metal-insulator transition" *Proc. 22nd Int School Theoretical Physics*, Ustron, 10-15 Sept 1998; *Mol Phys Rept*, **24**, 150-7 (1999). (invited) S Washburn, NJ Kim, KP Li and D Popovic.
115. "Effect of Local Magnetic Moments on the Metallic Behavior in Two Dimensions," *Phys Rev Lett*, **83**, 368-71 (1999). XG Feng, D Popovic, S Washburn.
116. "A new metal in two dimensions," *Phys Rev Lett*, **86** (2001) 2625-8. XG Feng, D Popovic, S Washburn, V Dobrosavljevic.
113. "Scaling and universal behavior near the two-dimensional metal-insulator transition" *Proc. 22nd Int School Theoretical Physics*, Ustron, 10-15 Sept 1998; *Mol Phys Rept*, **24**, 150-7 (1999). (invited) S Washburn, NJ Kim, KP Li and D Popovic.
115. "Effect of Local Magnetic Moments on the Metallic Behavior in Two Dimensions," *Phys Rev Lett*, **83**, 368-71 (1999). XG Feng, D Popovic, S Washburn.
116. "A new metal in two dimensions," *Phys Rev Lett*, **86** (2001) 2625-8. XG Feng, D Popovic, S Washburn, V Dobrosavljevic.
128. "Effects of a Parallel Magnetic Field on the Metal-Insulator Transition in a Dilute Two-Dimensional Electron System," *Phys Rev Lett*, **88**, 136402 (2002). K. Eng, X.G. Feng, D. Popovic, and S. Washburn.
131. "Phase coherence at high magnetic fields," to appear in *Semiconductors at High Magnetic Field*, edited by F Herlach (Springer, 2003). DV Khveshchenko and S Washburn.
121. "Scaling laws, phase diagram, localized moments and Kondo effect in two-dimensional metals," *Proc Localisation 1999*, Hamburg, 29 July - 3 Aug 1999. *Annalen Phys.* **8** 569-78 (1999), (invited) S Washburn, NJ Kim, XG Feng and D Popovic,

Unrefereed articles:

111. "Emergence of the Metallic State in Two Dimensions," *Proc Int Conf Phys Semiconductors XXIV*, Jerusalem, 1998. XG Feng, D Popovic and S Washburn.
117. "Suppression of the metallic behavior in two dimensions by spin-flip scattering," in *Quantum Physics at the Mesoscopic Scale*, eds. DC Glatli, M Sanquer, and J Tran Thanh (Editions Frontieres, 1999). XG Feng, D Popovic, S Washburn.
119. "A new metallic state in two dimensions," *Proc EP2DS 13*, Ottawa, 1999. *Physica E* **6**, 280-3 (2000). XG Feng, D Popovic, S Washburn, V Dobrosavljevic.
122. "Effects of parallel magnetic field on the novel new metallic behavior in two dimensions," *Proc Int Conf Phys Semiconductors 25*, 2000. to appear. K Eng, XG Feng, D Popovic, and S Washburn.

Preprints:

112. "Phase diagram and validity of one-parameter scaling near the two-dimensional metal-insulator transition," *subm. Phys Rev Lett*, cond-mat/9809357. Nam-Jung Kim, D Popovic, S Washburn.
130. "Hopping conductivity near the 2D metal-insulator transition," *Phys Rev B*, Submitted..NJ Kim and S Washburn.

Invited Talks:

Colloquia:

U Va, Nov 1998
UCincinnati Oct 13, 1998
UClemson Nov 30, 1999
NC State Univ, Mar 2000

Meetings and Conferences:

Ustron Sept 15, 1998
Hamburg Aug 3, 1998
Hamburg Sept 7 2000

Contributed talks:

APS LA 1998
[O11.07 Metal-Insulator Transition in small Si MOSFETs](#)

Kuo-Ping Li, Nam-Jung Kim, Sean Washburn (Dept. of Physics and Astronomy, The University of North Carolina at Chapel Hill), Dragana Popović (National High Magnetic Field Laboratory, Florida State University)

O11.08 [Effects of Disorder and Magnetic Field on a Two-Dimensional Metal-Insulator Transition](#)

Dragana Popović (National High Magnetic Field Laboratory, Florida State University), A. B. Fowler (IBM Research Division, T. J. Watson Research Center), S. Washburn (Dept. of Physics and Astronomy, University of North Carolina at Chapel Hill)

APS Atlanta 1999

LC30.03 [Suppression of the metallic behavior in two dimensions by spin-flip scattering](#)

Xiang Guang Feng, Dragana Popović (National High Magnetic Field Laboratory, Florida State University), S. Washburn (Dept. of Physics and Astronomy, University of North Carolina at Chapel Hill)

APS Minneapolis 2000

[G20.002] [Effects of a parallel magnetic field on the novel two-dimensional metallic behavior](#)

K. Eng (National High Magnetic Field Laboratory, FSU, Tallahassee, and Dept. of Physics and Astronomy, UNC-CH, Chapel Hill), X. G. Feng, D. Popović (National High Magnetic Field Laboratory, FSU, Tallahassee), S. Washburn (Dept. of Physics and Astronomy, UNC-CH, Chapel Hill)

[G20.013] [Novel metallic behavior in two dimensions](#)

X. G. Feng, D. Popović (National High Magnetic Field Laboratory, FSU, Tallahassee), S. Washburn (Dept. of Physics and Astronomy, UNC-CH, Chapel Hill), V. Dobrosavljević (National High Magnetic Field Laboratory, FSU, Tallahassee)

APS Seattle, 2001

Y16.006 [Effects of Parallel Magnetic Fields on "Non-ideal" Si MOSFETs](#)

Kevin Eng (National High Magnetic Field Laboratory, FSU, Tallahassee, and Dept. of Physics and Astronomy, UNC-CH, Chapel Hill), Dragana Popović (National High Magnetic Field Laboratory, FSU, Tallahassee), Sean Washburn (Dept. of Physics and Astronomy, UNC-CH, Chapel Hill)

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